



## SISAL AND HENEQUEN, PLANTS YIELDING FIBER FOR BINDER TWINE

By LYSTER H. DEWEY, *Senior Botanist in Charge, Division of Fiber Plant  
Investigations, Bureau of Plant Industry*

### CONTENTS

	Page		Page
Introduction.....	1	Henequen.....	7
Sisal.....	1	Description.....	7
Description.....	1	Origin and distribution.....	8
Origin and distribution.....	2	Climate.....	8
Climate.....	3	Soils.....	8
Soils.....	3	Clearing the land.....	8
Clearing the land.....	3	Planting.....	8
Propagation.....	3	Cultivation.....	9
Planting.....	4	Harvesting.....	9
Cultivation.....	4	Cleaning the fiber.....	10
Intercropping.....	4	Yield.....	10
Harvesting.....	4	Uses.....	11
Cleaning the fiber.....	4	Market and statistics.....	11
Yield.....	5	Size and location of plantations.....	11
Uses.....	5	By-products.....	12
Market and statistics.....	5		

### INTRODUCTION

The two hard fibers, sisal and henequen, are both commonly known in the market by the name sisal, or they are merely distinguished by the names Mexican sisal or Yucatan sisal for henequen, and African sisal, Java sisal, and Bahama sisal for the true sisal. The prices quoted indicate a difference in value. The true sisal commands a higher price except in the case of Bahama sisal, which is poorly prepared.

Sisal and henequen fibers are obtained from the leaves of two closely related but distinct species of the genus *Agave*. Both species originated in the Yucatan Peninsula, and they are not known elsewhere except as introduced plants. Both are cultivated on large plantations in the Tropics, and the fibers are cleaned by means of the same types of machines. Both fibers are used in the manufacture of binder twine and other hard fiber twines, and ropes of small diameter.

### SISAL

#### DESCRIPTION

The sisal plant, *Agave sisalana* Perrine (fig. 1), has dark-green leaves 30 to 60 inches long and 4 to 5½ inches wide, smooth on the margins or with very small marginal prickles. Each leaf terminates

in a dark chestnut terminal spine about 1 inch long by three-sixteenths inch thick. The leaves all originate in the erect bud in the middle of the plant and attain their full length before splitting away from the bud. The point of growth is at the base of the leaves in the bud. The oldest leaves are the outer or lower ones. A flower stalk grows up through the center of the bud when the plants are 5 to 10 years old. This flower stalk attains a height of 15 to 25 feet with slender ascending branches bearing at their forked ends erect clusters of light-yellow flowers. The flowers are followed by bulbils, but never by seed pods. The leaves of the bulbils often have small marginal prickles. The plants die after flowering.

#### ORIGIN AND DISTRIBUTION

Both sisal and henequen plants were introduced from Campeche, Mexico, and planted at Coconut Grove and on Indian Key in southern

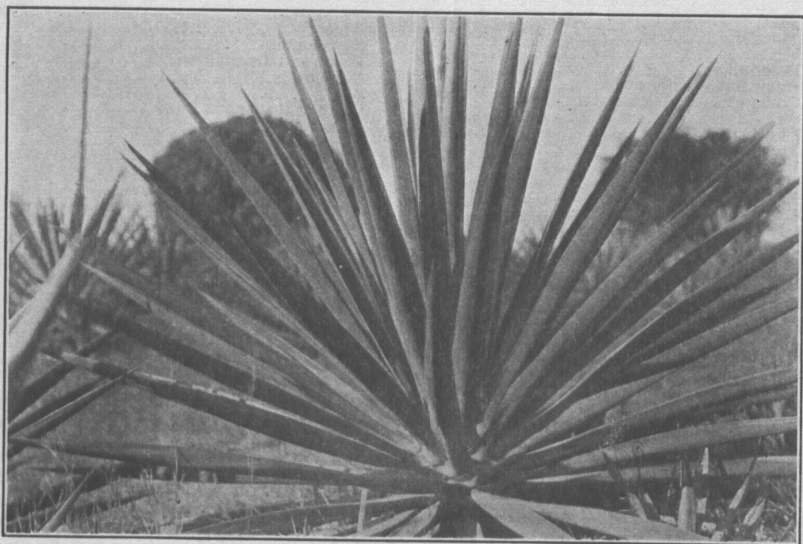


FIGURE 1.—Well-developed sisal plant, *Agave sisalana*, 4½ years old, with 97 leaves 40 to 50 inches long

Florida by Dr. Henry Perrine in 1834 to 1838. Few henequen plants survived, but the sisal plants grew and spread to many places on the keys and along the coast from Point Jupiter on the east around to Tampa on the west. Bulbils from these plants, naturalized in Florida, have been distributed to many tropical countries. Regulations, very strictly enforced by fiber producers in Yucatan and Campeche, have prevented the exportation of bulbils or suckers from the Yucatan Peninsula. All sisal plants may be traced either directly or indirectly to Florida.

Sisal is now regularly cultivated on large plantations in Kenya Colony, Tanganyika, Portuguese East Africa, Senegal, Dahomey, Sumatra, Java, India, and Haiti. The most extensive production is in tropical east Africa and in Java and Sumatra. Numerous efforts to establish the production of sisal fiber in Florida on a commercial scale have proved unsuccessful.

## CLIMATE

Sisal plants require a tropical climate. While the plants often survive temperatures of 2° to 15° below freezing, they are often injured by cold, even above freezing. There are no commercial sisal plantations outside the Tropics. Sisal endures drought better than most other tropical crops except henequen, but it endures excessive moisture better than henequen. Sisal grows in well-drained soils in Java with an annual rainfall of more than 100 inches. Dry air and abundant sunshine are desired for drying the fiber. Hurricanes sometimes break down the plants, but these storms are less injurious to sisal and henequen than to most other tropical crops.

## SOILS

Sisal grows well on a great variety of soils. It requires good drainage, a fair degree of fertility, and sufficient lime for an alkaline



FIGURE 2.—Nursery of sisal plants, *Agave sisalana*, 18 to 27 inches high and ready for transplanting to the field, 19 months after planting the bulbils

reaction. Heavy clays or impervious soils are to be avoided. It will not endure inundation except for very brief periods.

## CLEARING THE LAND

The land must be thoroughly cleared, for sisal will not endure shade. All trees and bushes are cut, and the land is burned over as thoroughly as possible. Most of the plantations are plowed, and often hoed crops, like corn or beans, are cultivated before setting out the sisal plants.

## PROPAGATION

Sisal plants are propagated either by bulbils (also called pole plants) produced on the flower stalk, or by suckers which grow up from the rootstocks. The bulbils are cultivated 12 to 24 months in a nursery (fig. 2) before transplanting to the field. Suckers are

either transplanted directly in the field, or they are cultivated in a nursery to produce more vigorous plants and afford opportunity for selection. The bulbils 2 to 4 inches long are produced in abundance, often 2,000 to 3,000 on one "pole" or flower stalk. They are very hardy and may be transported long distances with little loss. Bulbils are especially adapted for starting new plantations at a distance from the source of supplies. From 2 to 10 suckers per year are produced by each plant after the first year, so that after a plantation is started it may be enlarged by both suckers and bulbils. Numerous experiments have demonstrated that there is no apparent difference between plants produced from suckers and those from bulbils.

#### PLANTING

The land is marked in rows or double rows about 9 feet apart, with drives about 300 feet apart at right angles to the rows, and main drives leading to the mill. Young sisal plants 12 to 24 inches high are selected in the nursery so as to have blocks of uniform size in the field. Roots and outer leaves are trimmed off, and the plants are set out  $1\frac{1}{2}$  to 5 feet apart in the row, or at the rate of 1,000 to 2,500 plants per acre.

#### CULTIVATION

Weeds and especially twining vines which will bind the sisal leaves in the bud must be kept down, and soils not otherwise loose must be cultivated to allow aeration. Much of this cultivation is done with machetes or with hand hoes. On some plantations mules, equipped with leather leggings to protect them from the sharp spines on the sisal leaves, draw cultivators like those used for cultivating corn. Cultivators drawn by tractors are used in increasing numbers.

#### INTERCROPPING

Peppers, beans, or other low-growing crops may be grown between the sisal rows the first year. The plants must not be tall enough to shade the sisal. In Java low cover crops are often grown during the rainy season to be plowed under during the dry season.

#### HARVESTING

The first crop of leaves is cut 18 to 36 months after the young plants are set out in the field. Afterwards about 15 to 18 leaves are cut from each plant twice each year for a period of 4 to 6 years, or until many of the plants send up flower stalks and die. The leaves are cut one at a time with an ordinary butcher knife or with a curved knife like a pruning hook on a handle about 20 inches long. One man with an assistant to tie the leaves in bundles and carry them to the roadway will cut 3,000 to 5,000 leaves per day.

#### CLEANING THE FIBER

The bundles of leaves are taken in carts or by tram cars directly to the factory, where they are put through the fiber-cleaning machine, usually within 12 hours after cutting. There are a half dozen different types of fiber-cleaning machines, all operating on the same

general principle. The leaves are fed sidewise at the rate of 5,000 to 15,000 per hour. They are grasped near the middle by chains or belts carrying one end of the leaf past a rapidly revolving drum with lugs that beat and scrape away the pulp. A curved plate holds the leaves against the lugs of the drum. After passing the first drum the mechanism carrying the leaf is released as a second pair of chains or belts grasps the fiber thus cleaned and carries the other end of the leaf past a second drum. The fiber comes from the machine sidewise, clean, and straight. Most of the machines are equipped with pipes, so that streams of water wash the fiber as it is being cleaned, and sometimes it is washed further in running water immediately after leaving the machine. It is then dried in the sun, or on some plantations by means of centrifugals and driers. After drying, much of the best sisal is brushed by means of brushing machines. It is usually sorted into about three grades according to length and quality.

#### YIELD

The yield per acre varies with the number of plants, vigor of growth, and efficiency in cleaning. It varies on different plantations from about 800 to 2,000 pounds of clean marketable fiber per acre each year during the period of production.

#### USES

Sisal is used, either alone or mixed with abaca (Manila hemp), for making binder twine (600 to 650 feet per pound). It is also used in hammocks, general purpose ropes, and to some extent in marine cordage, but when wet it swells more than abaca, and this interferes with its use in pulley blocks.

#### MARKET AND STATISTICS

There has been a generally increasing demand for sisal fiber during the last 20 years, and especially since manufacturers and users have learned to appreciate its merits more fully. Like all fibers in the American market, it is quoted in cents per pound delivered in New York. The increasing production and range of quotations are indicated in Table 1.

TABLE 1.—*World production and range of prices of sisal, 1909–1913 and 1926–1930*

Years	Metric tons	Range of New York quotations (cents per pound)	
		Highest	Lowest
1909–1913 (5-year average).....	23, 700	(1)	(1)
1926.....	76, 700	10½	9½
1927.....	94, 100	9½	8½
1928.....	98, 100	9½	7¾
1929.....	122, 100	10½	8½
1930.....	130, 000	8½	4¾

<sup>1</sup> Not quoted separately.

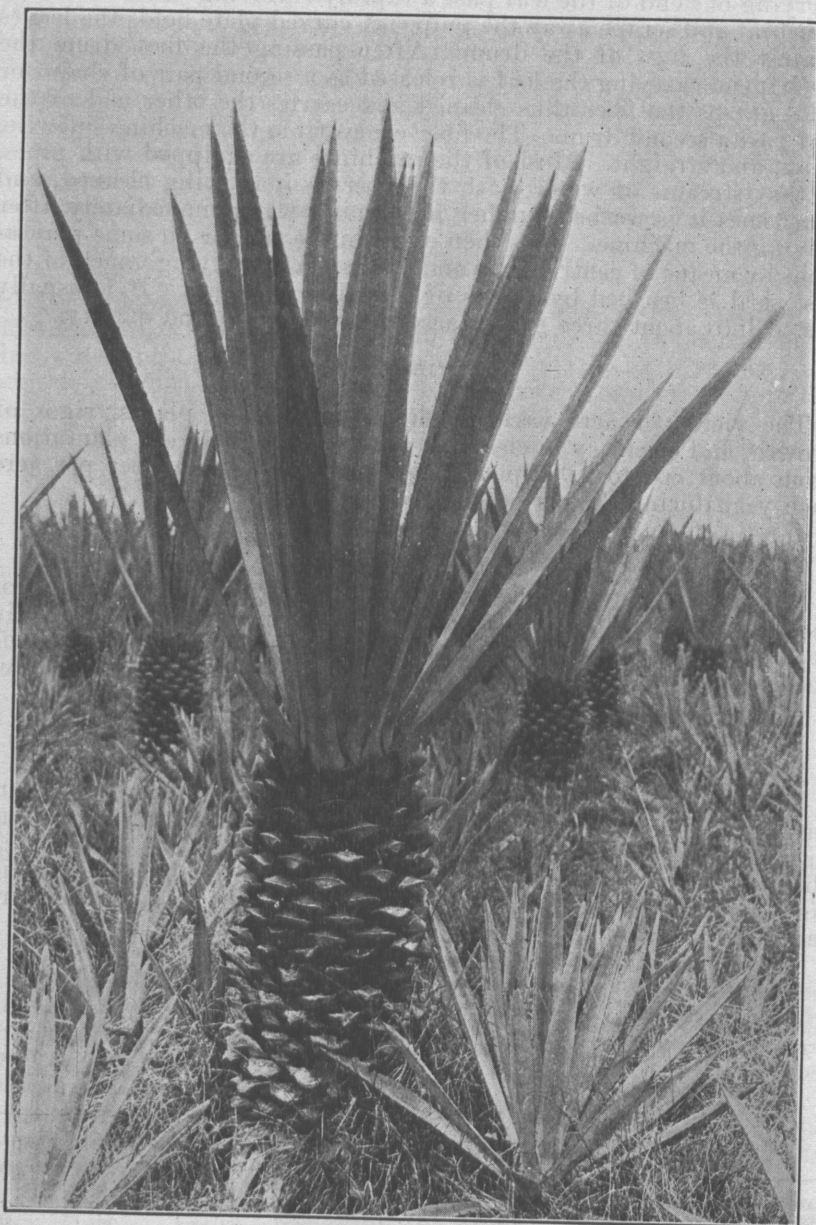


FIGURE 3.—Typical 10-year-old henequen plant, *Agave fourcroydes*, from which nine crops of leaves have been cut, with suckers 2 to 3 years old and large enough to be transplanted

## HENEQUEN

The name henequen (pronounced hen-e-ken) is used in the Yucatan Peninsula to designate all the various species of *Agave* and *Furcraea* which grow there. It is used especially to designate the species that is cultivated there for fiber production on more than a half million acres, and it is not used outside of Yucatan to designate sisal, which is cultivated on more than a half million acres in other countries but to only a limited extent in the Yucatan Peninsula.

## DESCRIPTION

The henequen plant, *Agave fourcroydes* Lem. (fig. 3), has gray leaves 30 to 60 inches long and 4 to 5 inches wide, with hooked



FIGURE 4.—Bulbils and seed pods growing on the same branch of henequen, *Agave fourcroydes*

prickles about one-eighth inch long and one-half to 1 inch apart on the margins. The terminal spine is about 1 inch long and about one-fourth inch thick and nearly black. The henequen leaves are generally thicker and firmer in texture than those of sisal. The plant starts with a rosette of leaves from a very short trunk, but in old plants the trunks are sometimes 6 feet tall, with the rosette of leaves at the top. Henequen plants live 10 to 20 years or even longer. Many die without flowering. Others send up a flower stalk or "pole" 15 to 30 feet high with rather stout nearly horizontal branches, bearing erect clusters of light-yellow flowers. The flowers are followed by either seed pods or bulbils or often by both in the same cluster. (Fig. 4.) The plants die after flowering. From 1 to 10 suckers grow up from the rootstocks of each plant each year. (Fig. 3.)

## ORIGIN AND DISTRIBUTION

The henequen plant is regarded as native in the Yucatan Peninsula, but it is not known in a wild condition except as an escape from cultivation. It is cultivated in Yucatan and Campeche, and to a less extent in the States of Chiapas, Tamaulipas, and Sinaloa in Mexico, and in Cuba. It has been introduced into Porto Rico, Jamaica, and tropical east Africa, but aside from these places it is rarely found even in botanical gardens.

## CLIMATE

The henequen plantations in Yucatan are in north latitude  $20^{\circ}$  to  $21^{\circ} 50'$ , and those in Cuba in north latitude  $20^{\circ}$  to  $23^{\circ}$ , all within the Tropics and in areas entirely free from frost. Henequen plantations have been carried on during the last 30 years almost on the Tropic of Cancer near Victoria, Tamaulipas, where there are light frosts nearly every winter. The bulbils and tips of the leaves are sometimes injured by the cold weather. The average annual rainfall at that point is about 32 inches, but it is usually very dry in winter. The average annual rainfall in the henequen-growing areas of Yucatan is about 30 inches, and the lowest recorded temperature is  $48^{\circ}$  F. The climate is arid, with an abundance of bright sunshine. Along the northern coast of Cuba where henequen is cultivated, the temperature ranges from about  $40^{\circ}$  to  $100^{\circ}$  but rarely falls below  $60^{\circ}$ . The annual rainfall averages about 50 to 55 inches.

Rains and fogs interfere with drying the fiber. Henequen endures drought better than sisal, but in a protracted drought its leaves become leathery, making it very difficult to clean the fiber.

## SOILS

Henequen requires a soil with good natural drainage. The plantations in Yucatan are mostly on porous lime rock through which water from rains quickly sinks to the underground river 10 to 20 feet below the surface. There are no streams or natural ponds on the surface in northern Yucatan. The henequen plantations in Cuba are mostly on soils with frequent limestone outcropping. Henequen does not grow well on granitic soils, magnesium soils, or acid sandy soils.

## CLEARING THE LAND

Henequen grows best in the full sunlight. It is necessary, therefore, to cut all trees and bushes. The brush, herbaceous weeds, and grass are all burned, and the land is cleared as thoroughly as possible. Twining vines and perennial bushes should be exterminated if possible before planting. Plowing is practiced where possible, but most henequen plantations are on lands too rocky to be plowed.

## PLANTING

The plantations are subdivided into convenient units, usually in fields of 1,000 "mecates" (about 100 acres) in Yucatan, or in "caballerias" (about 33 acres) in Cuba. The land is carefully surveyed and marked in lines about 11 feet (4 varas) apart, and the plants are set out about 50 inches ( $11\frac{1}{2}$  varas) in the row, making

96 plants per mecate, or about 960 plants per acre. Particular attention is given to the size of the unit and the number of plants, for this is the basis of all field labor and estimates of production.

Suckers about 18 inches high are used for planting. The roots and outer leaves are trimmed off. (Fig. 5.) Suckers may be planted at once, or they may remain out of the ground two or three months. Small holes are dug, often with a pick, in rocky land, and the bulb is set and partly covered with earth. In rocky land it is often necessary to prop up the suckers with small stones. After planting, the field is inspected at frequent intervals, and suckers that have fallen over are straightened up and those that fail to grow are replaced.

#### CULTIVATION

The soils in most henequen plantations are too rocky for regular cultivation. Grasses, herbaceous weeds, and bushes are kept down by cutting with machetes, and often bushes and perennial vines are

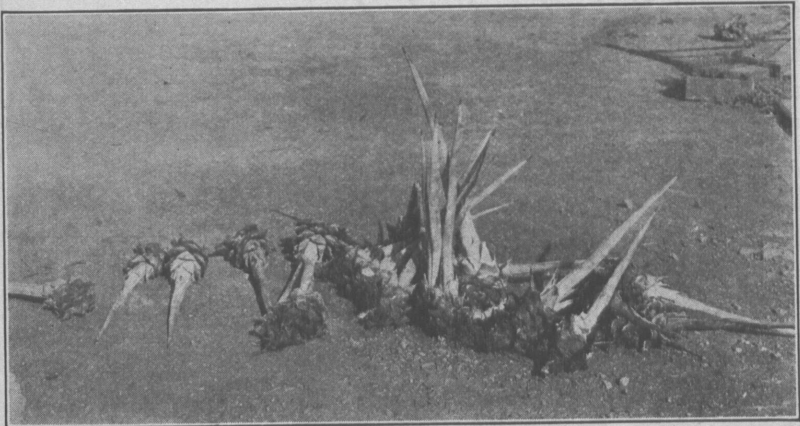


FIGURE 5.—Suckers of henequen, trimmed ready for planting

dug out with picks or grub hoes to exterminate them. It is usually necessary to clear the land of weeds two to four times each year until the first harvest of leaves, or even oftener in regions of greater rainfall. Afterwards the land is cleared at the time of each harvest.

#### HARVESTING

In Yucatan the first leaves are cut in the sixth or seventh year, and afterwards usually two crops per year are cut for periods varying from 10 to 20 years, or until many of the plants cease to put forth good leaves. In Cuba, with more rain, the plants grow more rapidly, and the first crop is cut usually in the fourth year after planting, and succeeding crops are cut every six months thereafter for a period of 10 to 15 years.

The leaves are cut one at a time by hand with an ordinary butcher knife. (Fig. 6.) Curved knives are often used. The terminal spine and marginal prickles are trimmed off, and the leaves are tied in bundles of 40 to 50 per bundle. One man, with two assistants to

trim off the prickles, count, and tie the leaves in bundles and carry them to the roadway, may cut 3,000 to 4,000 leaves per day.

#### CLEANING THE FIBER

The bundles of henequen leaves are brought directly from the field to the fiber-cleaning machines. Plantation railways with small cars, similar to those on sugar plantations, are generally used for transporting the leaves.

The fiber is cleaned by the same types of machines as those for cleaning sisal. The pulp of the henequen leaf is firmer than that of sisal leaves, and more power is required for cleaning the fiber. Where water is available the machines are often equipped with pipes to wash the fiber as it passes the scraping drums, but the fiber is not washed after leaving the machine, and it is rarely brushed after



FIGURE 6.—Harvesting leaves from the henequen plant at Hacienda Ticopo, near Acanceh, Yucatan. The leaves are cut one at a time by means of an ordinary butcher knife, and usually two tiers are cut at each harvest

drying. Some efforts are made to induce the growers to pack the fiber in uniform 400-pound bales, but with the presses in use on the different plantations the bales vary from 375 to 500 pounds. Statistics are commonly given in number of bales, and the weights computed from them are therefore only approximations.

#### YIELD

The yield of fiber per acre may vary with the variety of the plant, the number of plants per acre, and the size and quality of the leaves. The clean, dry fiber may range from  $3\frac{1}{2}$  to 5 per cent of the weight of the leaves. The average annual yield ranges from about 700 to 1,200 pounds per acre during the producing period on different plantations in Yucatan. The average annual yield is somewhat higher in Cuba, but the producing period is shorter.

## USES

Henequen is used more than any other fiber in the manufacture of binder twine for harvesting grain. It is also used in halter ropes, guy ropes, and general-purpose ropes, but owing to its harshness and tendency to swell when wet it is not satisfactory for use in pulley blocks.

## MARKET AND STATISTICS

There was an increasing demand for henequen fiber for use in binder twine from about 1888 to 1916, when the prices, like those of nearly all products, were abnormally high. Since then there have been periods of overproduction and also periods of scarcity, resulting in wide fluctuations in prices. Since four to seven years must elapse after planting before the first crop of leaves can be cut, and the harvests can not be omitted without loss, it is impossible to adjust production quickly in accordance with demand.

The increasing use of the "combine" (combined harvester-thresher) for harvesting grain is reducing the demand for binder twine, and the rapidly increasing production of sisal has resulted in serious competition for henequen. (Table 2.)

TABLE 2.—*World production and range of prices of henequen, 1909–1913 and 1926–1930*

Year	Metric tons	Range of New York quotations (cents per pound)	
		Highest	Lowest
1909–1913 (5-year average) .....	106, 800	7½	3¾
1926 .....	117, 000	9½	8½
1927 .....	175, 000	7½	6½
1928 .....	113, 700	7¼	6½
1929 .....	104, 000	8½	7½
1930 .....	107, 000	8¼	4½

## SIZE AND LOCATION OF PLANTATIONS

A plantation of either sisal or henequen should be large enough to keep a fiber-cleaning machine in operation at least six months each year. From 10 to 20 acres producing 100,000 to 200,000 leaves are required to keep one machine in operation one day. The most profitable plantations are those having more than one machine in operation throughout the year. In addition to the areas in actual production, allowance must be made for young plants coming on and fields of old plants dying out.

Since 100 pounds of leaves must be taken from the field to the cleaning mill for each 3 or 4 pounds of dry marketable fiber, it is essential that the land be reasonably level to afford easy transportation. The fiber-cleaning mill may be located at the lowest central part of the plantation, but consideration must be given to space for drying the fiber close to the mill and also to the disposal of the bagasse.

## BY-PRODUCTS

Fiber recovered from the waste from brushing sisal is sold as sisal tow. It is used in twines. Waste fiber cleaned from the bagasse is used to a very limited extent for upholstery tow. Numerous experiments have shown that industrial alcohol may be produced from the bagasse, but not in sufficient quantities to be profitable. The bagasse contains small percentages of lime and potash, and it is often spread out on the plantations for fertilizer. The bagasse is sometimes used for fuel, but as ordinarily produced it contains too much moisture to be satisfactory for this purpose.